Chapter #1: Getting Started

HOW MANY MICROCONTROLLERS DID YOU USE TODAY?

A microcontroller is a kind of miniature computer that you can find in all kinds of gizmos. Some examples of common, every-day products that have microcontrollers built-in are shown in Figure 1-1. If it has buttons and a digital display, chances are it also has a programmable microcontroller brain.

Figure 1-1
Every-Day Examples of Devices that Contain Microcontrollers

Try making a list and counting how many devices with microcontrollers you use in a typical day. Here are some examples: if your clock radio goes off, and you hit the snooze button a few times in the morning, the first thing you do in your day is interact with a microcontroller. Heating up some food in the microwave oven and making a call on a cell phone also involve operating microcontrollers. That's just the beginning. Here are a few more examples: turning on the television with a handheld remote, playing a handheld game, using a calculator, and checking your digital wristwatch. All those devices have microcontrollers inside them that interact with you.

THE BASIC STAMP 2 - YOUR NEW MICROCONTROLLER

Parallax, Inc.'s BASIC Stamp® 2 module shown in Figure 1-2 has a microcontroller built onto it. It's the black chip with lettering on it that reads "PIC16C57". The rest of the components on the BASIC Stamp module are also found in consumer appliances you use every day. All together, they are correctly called an embedded computer system. This name is almost always shortened to just "embedded system". Frequently, such modules are commonly just called "microcontrollers."

The activities in this text will guide you through building circuits similar to the ones found in consumer appliances and high-tech gizmos. You will also write computer programs that the BASIC Stamp module will run. These programs will make the BASIC Stamp module monitor and control these circuits so that they perform useful functions.

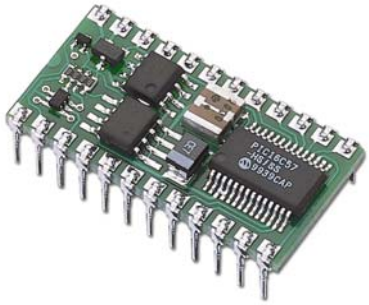


Figure 1-2
The BASIC Stamp® 2 Microcontroller Module

BASIC Stamp 2 modules are the most popular microcontrollers made by Parallax, Inc.

In this text, "BASIC Stamp" refers to Parallax Inc.'s BASIC Stamp® 2 microcontroller module. There are other BASIC Stamp modules, some of which are shown in Figure 1-3. Each BASIC Stamp module is color coded. The BASIC Stamp 2 is green. The BASIC Stamp 2e is red. The BASIC Stamp 2SX is blue, and the BASIC Stamp 2p is gold. Each variation on the BASIC Stamp 2 is slightly different, featuring higher speed, more memory, additional functionality, or some combination of these extra features.

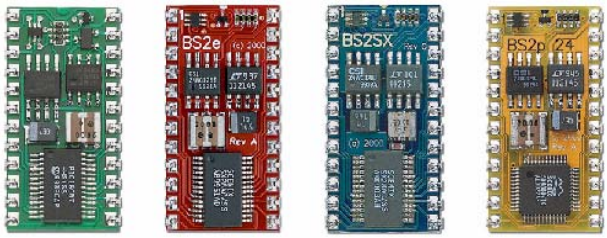


Figure 1-3
BASIC Stamp® Modules

From Left to Right: BASIC Stamp® 2, 2e, 2SX, and 2p

AMAZING INVENTIONS WITH BASIC STAMP MICROCONTROLLERS

Consumer appliances aren't the only things that contain microcontrollers. Robots, machinery, aerospace designs and other high-tech devices are also built with microcontrollers. Let's take a look at some examples that were created with BASIC Stamp modules.

Robots have been designed to do everything from helping students learn more about microcontrollers, to mowing the lawn, to solving complex mechanical problems. Figure 1-4 shows two example robots. On each of these robots, students use the BASIC Stamp 2 to read sensors, control motors, and communicate with other computers. The robot on

the left is Parallax Inc.'s Boe-Bot™. The projects in the *Robotics with the Boe-Bot* text can be tackled using the Boe-Bot after you've worked through the activities in this one. The robot on the right was built by a group of students and entered into a First Robotics competition. The goal of the contest is different each year. In the example shown, the goal was to see which group's robot could sort colored hoops the fastest.

Figure 1-4
Educational Robots

Parallax Boe-Bot™ (left)
First Competition Robot (right)

Other robots solve complex problems, such as the autonomous remote flight robot shown at the left of Figure 1-5. This robot was built and tested by mechanical engineering students at the University of California, Irvine. They used a BASIC Stamp module to help it communicate with a satellite global positioning system (GPS) so that the robot could know its position and altitude. The BASIC Stamp also read level sensors and controlled the motor settings to keep the robot flying properly. The mechanical millipede robot on the right was developed by a professor at Nanyang Technical University, Singapore. It has more than 50 BASIC Stamp modules, and they all communicate with each other in an elaborate network that helped control and orchestrate the motion of each set of legs. Robots like this not only help us better understand designs in nature, but they may eventually be used to explore remote locations, or even other planets.

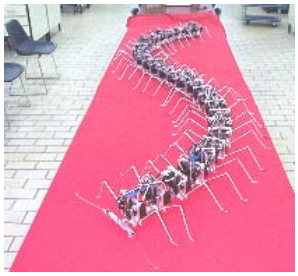


Figure 1-5
Examples of Research Robots that Contain Microcontrollers

Autonomous flying robot at UC Irvine (left) and Millipede Project at Nanyang University (right)

With the help of microcontrollers, robots will also take on day-to-day tasks, such as mowing the lawn. The BASIC Stamp module inside the robotic lawn mower shown in Figure 1-6 helps it stay inside the boundaries of the lawn, and it also reads sensors that detect obstacles and controls the motors that make it move.

Figure 1-6
Robotic Lawn Mower

Prototype by the Robot Shop

Microcontrollers are also used in scientific, high technology, and aerospace projects. The weather station shown on the left of Figure 1-7 is used to collect environmental data related to coral reef decay. The BASIC Stamp module inside it gathers this data from a variety of sensors and stores it for later retrieval by scientists. The submarine in the center is an undersea exploration vehicle, and its thrusters, cameras and lights are all controlled by BASIC Stamp microcontrollers. The rocket shown on the right is one that was part of a competition to launch a privately owned rocket into space. Nobody won the competition, but this rocket almost made it! The BASIC Stamp controlled just about every aspect of the launch sequence.

Figure 1-7
High-tech and Aerospace Microcontroller Examples

Ecological data collection by EME Systems (left), undersea research by Harbor Branch Institute (center), and JP Aerospace test launch (right)

From common household appliances all the way through scientific and aerospace applications, the microcontroller basics you will need to get started on projects like these are introduced here. By working through the activities in this book, you will get to

experiment with and learn how to use a variety of building blocks found in all these high-tech inventions. You will build circuits for displays, sensors, and motion controllers. You will learn how to connect these circuits to the BASIC Stamp 2 module, and then write computer programs that make it control displays, collect data from the sensors, and control motion. Along the way, you will learn many important electronic and computer programming concepts and techniques. By the time you're done, you might find yourself well on the way to inventing a gizmo of your own design.

HARDWARE AND SOFTWARE

Getting started with BASIC Stamp microcontroller modules is similar to getting started with a brand-new PC or laptop. The first things that most people have to do when they get a new PC or laptop is take it out of the box, plug it in, install and test some software, and maybe even write some software of their own using a programming language. If this is your first time using a BASIC Stamp module, you will be doing all these same activities. If you are in a class, your hardware may already be all set up for you. If this is the case, your teacher may have other instructions. If not, this chapter will take you through all the steps of getting your new BASIC Stamp microcontroller up and running.

ACTIVITY #1: GETTING THE SOFTWARE

The BASIC Stamp Editor (version 2.0 or higher) is the software you will use in most of the activities and projects in this text. You will use this software to write programs that the BASIC Stamp module will run. You can also use this software to display messages sent by the BASIC Stamp that help you understand what it senses.

The BASIC Stamp Editor is free software, and the two easiest ways to get it are:

- **Download from the Internet:** Look for "BASIC Stamp Windows Editor version 2.0…" on the www.parallax.com → Downloads → BASIC Stamp Software page.
- **Included on the Parallax CD:** Follow the Software link on the Welcome page. Make sure the date printed on the CD is May 2003 or newer.

In a Hurry? Get your copy of the BASIC Stamp Windows Editor version 2.0 (or higher) and install it on your PC or laptop. Then, skip to: Activity #3: Setting Up the Hardware and Testing the System.

If you have questions along the way, Activity #1 can be used as a step-by-step reference for getting the software, and Activity #2 can be used as a reference for the installation procedure.

Computer System Requirements

You will need either a PC or laptop computer to run the BASIC Stamp Editor software. Getting started with BASIC Stamp programming is easiest if your PC or laptop has the following features:

- Microsoft Windows 95® or newer operating system
- A serial or USB port
- A CD-ROM drive, World Wide Web access, or both

USB Port Adapter If your computer only has USB ports, you will need a USB to Serial Adapter. See Appendix A: USB to Serial Adapter for details and installation instructions.

Downloading the Software from the Internet

It's easy to download the BASIC Stamp Editor software from the Parallax web site. The web page shown in Figure 1-8 may look different from the web page you see when you visit the site. Nonetheless, the steps for downloading the software should still be similar to these:

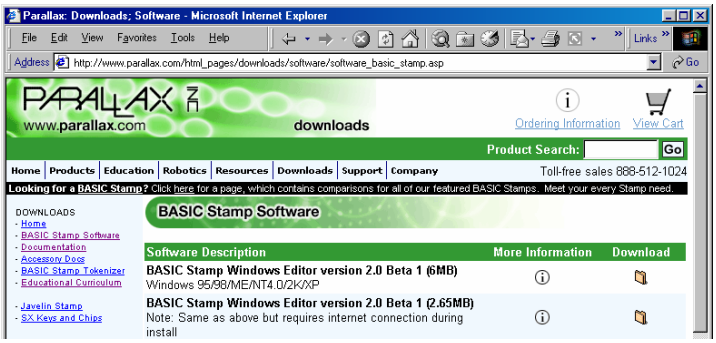
√ Using a web browser, go to www.parallax.com (shown in Figure 1-8).
√ Point at the *Downloads* menu to display the options.
√ Point at the *BASIC Stamp Software* link and click to select it.

Figure 1-8
The Parallax Web Site:

www.parallax.com

√ When you get to the BASIC Stamp Software page, find the most recent version of the BASIC Stamp Windows Editor download, with a version number of 2.0 or higher.

√ Click the *Download* icon. In Figure 1-9, the download icon looks like a file folder to the right of the description: "BASIC Stamp Windows Editor version 2.0 Beta 1 (6MB)".


Parallax: Downloads; Software - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Address http://www.parallax.com/html_pages/downloads/software/software_basic_stamp.asp
www.parallax.com
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Accessory Docs
BASIC Stamp Tokenizer
Educational Curriculum
Javelin Stamp
SX Keys and Chips
BASIC Stamp Software
Software Description
More Information
Download
BASIC Stamp Windows Editor version 2.0 Beta 1 (6MB)
Windows 95/98/ME/NT4.0/2K/XP
BASIC Stamp Windows Editor version 2.0 Beta 1 (2.65MB)
Note: Same as above but requires internet connection during install

Figure 1-9
The Parallax Web Site Downloads Page

√ When the File Download window shown in Figure 1-10 appears, select: *Save this program to disk.*

√ Click the *OK* button.

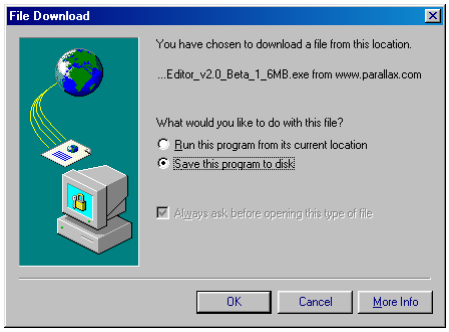

File Download
You have chosen to download a file from this location.
...Editor_v2.0_Beta_1_6MB.exe from www.parallax.com
What would you like to do with this file?
Run this program from its current location
Save this program to disk
Always ask before opening this type of file
OK
Cancel
More Info

Figure 1-10
File Download Window

Figure 1-11 shows the Save As window that appears next. You can use the *Save in* field to browse your computer's hard drives to find a convenient place to save the file.

√ After choosing where to save the file you are downloading, click the *Save* Button.

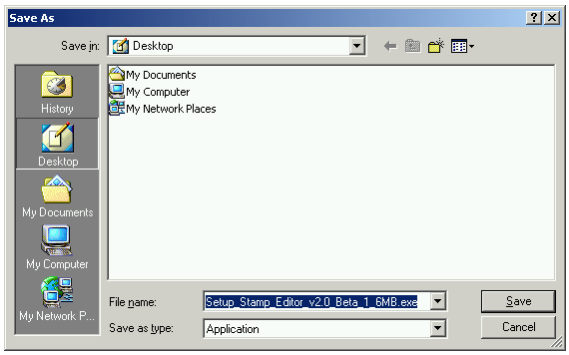


Figure 1-11
Save As Window

Selecting a place to save the file

√ Wait while the BASIC Stamp Editor installation program downloads (shown in Figure 1-12). This may take a while if you are using a modem connection.

√ When the download is complete, leave the window shown in Figure 1-13 open while you skip to the next section - Activity #2: Installing the Software.

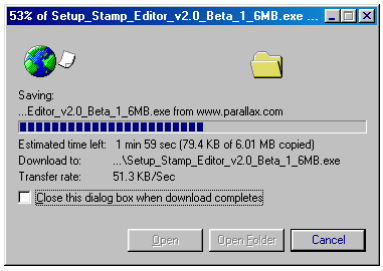


Figure 1-12: Download Progress Window

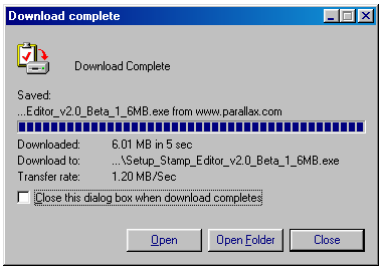


Figure 1-13: Download Complete

Finding the Software on the Parallax CD

You can also install the BASIC Stamp Editor from the Parallax CD, but it has to be May 2003 or newer so that you can get the version of the BASIC Stamp Editor that is compatible with the examples in this text. You can find the Parallax CD's Year and Month by examining the labeling on the front of the CD.

√ Place the Parallax CD into your computer's CD drive. The Parallax CD Welcome application shown in Figure 1-14 should run as soon as you load the CD into your computer's CD drive.

√ If the Welcome application does not automatically run, double-click *My Computer*, then double-click your CD drive, then double-click *Welcome*.

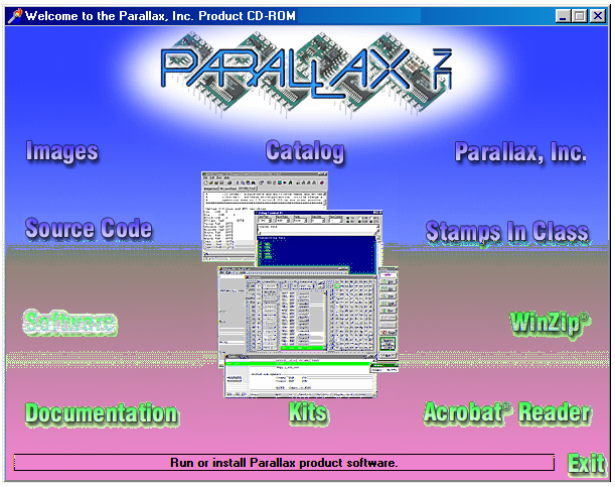


Figure 1-14
The Parallax CD Browser

√ Click the *Software* link shown in Figure 1-14.
√ Click the + next to the BASIC Stamps folder shown in Figure 1-15.
√ Click the + next to the Windows folder.
√ Click the floppy diskette icon labeled "Stamp 2/2e/2sx/2p/2pe (stampw.exe)".
√ Move on to Activity #2: Installing the Software.

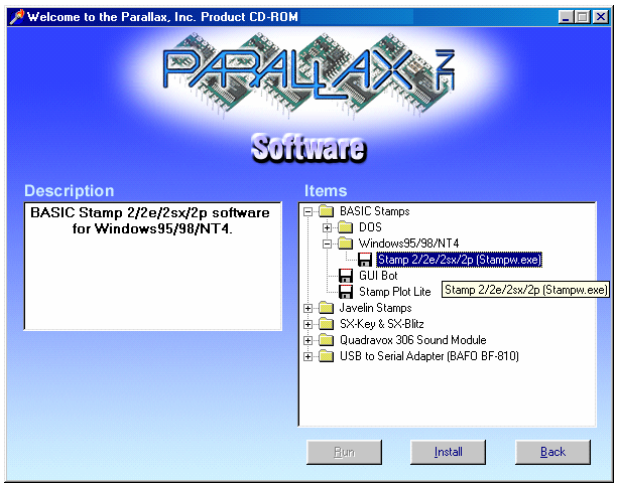


Figure 1-15
The Parallax CD Browser

Select the BASIC Stamp Editor installation program from the Software page.

Free downloads at the Parallax web site are included in the Parallax CD, but only up to the date the CD was created. The date on the front of the CD indicates when it was created. If the CD is just a few months old, you will probably have the most up-to-date material. If it's an older CD, consider requesting a new one from Parallax or downloading the files you need from the Parallax web site.

ACTIVITY #2: INSTALLING THE SOFTWARE

By now, you have either downloaded the BASIC Stamp Editor Installer from the Parallax web site or located it on the Parallax CD. Now let's run the BASIC Stamp Editor Installer.

Installing the Software Step by Step

√ If you downloaded the BASIC Stamp Editor Installer from the Internet, click the *Open* button on the Download Complete window shown in Figure 1-16.

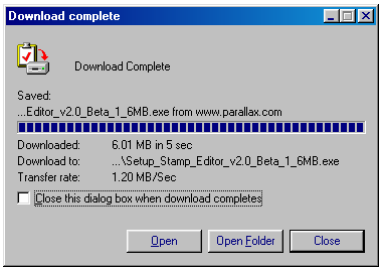


Figure 1-16
Download Complete Window

If you skipped here from the "Downloading the Software from the Internet" section, click the Open button.

√ If you located the software on the Parallax CD, click the *Install* button shown in Figure 1-17.

Figure 1-17
The Parallax CD Browser

Install button located near bottom of window.

√ When the BASIC Stamp Editor InstallShield Wizard window opens, click the *Next* button shown in Figure 1-18.

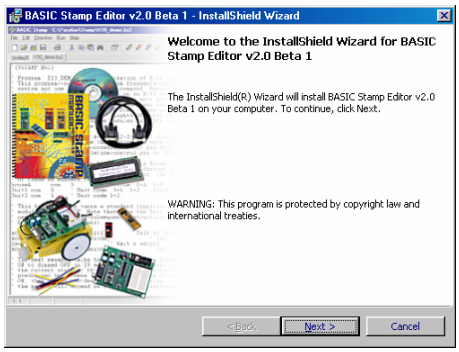

BASIC Stamp Editor v2.0 Beta 1 - InstallShield Wizard
Welcome to the InstallShield Wizard for BASIC Stamp Editor v2.0 Beta 1
The InstallShield(R) Wizard will install BASIC Stamp Editor v2.0 Beta 1 on your computer. To continue, click Next.
WARNING: This program is protected by copyright law and international treaties.
< Back
Next >
Cancel

Figure 1-18
InstallShield Wizard for the BASIC Stamp Editor

Click Next.

√ Select *Typical* for your setup type as shown in Figure 1-19.

√ Click the *Next* button.

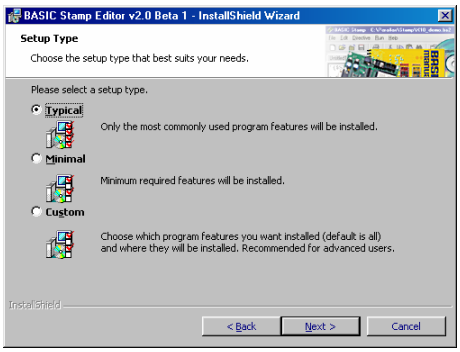

BASIC Stamp Editor v2.0 Beta 1 - InstallShield Wizard
Setup Type
Choose the setup type that best suits your needs.
Please select a setup type.
Typical
Only the most commonly used program features will be installed.
Minimal
Minimum required features will be installed.
Custom
Choose which program features you want installed (default is all) and where they will be installed. Recommended for advanced users.
InstallShield
< Back
Next >
Cancel

Figure 1-19
Setup Type

Click Typical, then click the Next button.

√ When the InstallShield Wizard tells you it is "Ready to Install the Program", click the *Install* button shown in Figure 1-20.

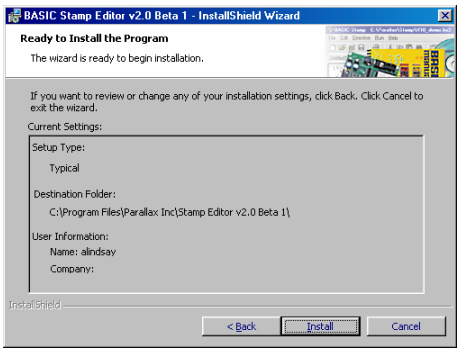

BASIC Stamp Editor v2.0 Beta 1 - InstallShield Wizard
Ready to Install the Program
The wizard is ready to begin installation.
If you want to review or change any of your installation settings, click Back. Click Cancel to exit the wizard.
Current Settings:
Setup Type:
Typical
Destination Folder:
C:\Program Files\Parallax Inc\Stamp Editor v2.0 Beta 1\
User Information:
Name: alindsay
Company:
InstallShield
< Back
Install
Cancel

Figure 1-20
Ready to Install.

Click the Install button.

√ When the InstallShield Wizard window tells you "InstallShield Wizard Completed", as shown in Figure 1-21, click *Finish*.

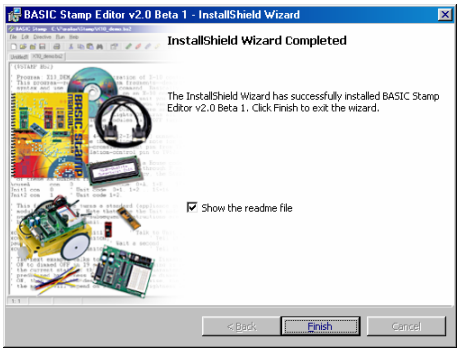

BASIC Stamp Editor v2.0 Beta 1 - InstallShield Wizard
InstallShield Wizard Completed
The InstallShield Wizard has successfully installed BASIC Stamp Editor v2.0 Beta 1. Click Finish to exit the wizard.
Show the readme file
< Back
Finish
Cancel

Figure 1-21
InstallShield Wizard Completed:

Click the Finish button.

ACTIVITY #3: SETTING UP THE HARDWARE AND TESTING THE SYSTEM

The BASIC Stamp module needs to be connected to power for it to run. It also needs to be connected to a PC so it can be programmed. After making these connections, you can use the BASIC Stamp Editor to test the system. This activity will show you how.

Introducing the BASIC Stamp®, Board of Education®, and HomeWork Board™

Parallax Inc.'s Board of Education® carrier board shown in Figure 1-22 next to a BASIC Stamp module. As mentioned earlier, the BASIC Stamp is a type of very small computer. This very small computer plugs into the Board of Education carrier board. As you will soon see, the Board of Education makes it easy to connect a power supply and serial cable to the BASIC Stamp module. In later activities, you will also see how the Board of Education makes it easy to build circuits and connect them to your BASIC Stamp module.

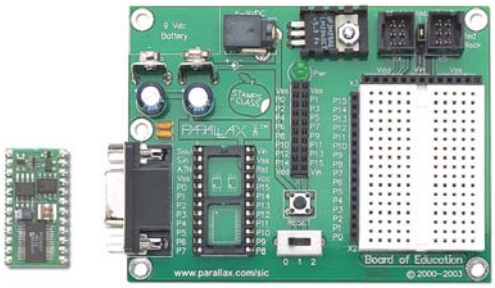


Figure 1-22
BASIC Stamp® 2 Microcontroller Module (left) and Board of Education ® Carrier Board (right)

Parallax, Inc.'s BASIC Stamp HomeWork Board™ is shown in Figure 1-23. This board is like a Board of Education with the BASIC Stamp 2 module built-in. Its surface-mounted components are visible to the left of the white breadboard area. You can use either the Board of Education with a BASIC Stamp module or the BASIC Stamp HomeWork Board as your project platform for the activities in this text.

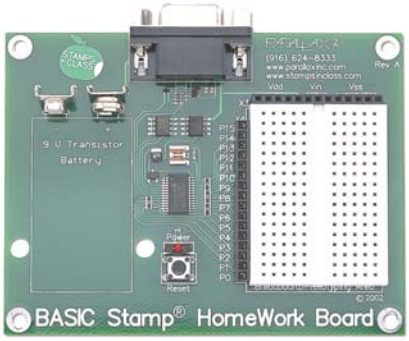


Figure 1-23
BASIC Stamp® HomeWork Board™ Project Platform.

Learn more about the features, parts and functions of BASIC Stamp modules, Board of Education carrier boards, and the HomeWork Board project platform. See Appendix C: BASIC Stamp and Carrier Board Components and Functions on page 307.

Required Hardware

(1) BASIC Stamp 2 module AND
(1) Board of Education
- or -
(1) BASIC Stamp HomeWork Board

(1) 9 V battery
(1) strip of 4 adhesive rubber feet
(1) Serial cable

Start with a new or fully charged 9 V battery. Avoid all the confusion a dead battery can cause. Start with a new alkaline battery or a rechargeable battery that has recently been fully recharged.

CAUTION! Before using an AC adapter, "battery replacer", or DC supply:

√ Consult Appendix D: Batteries and Power Supplies on page 311 to make sure the supply you use is appropriate for the activities in this text.

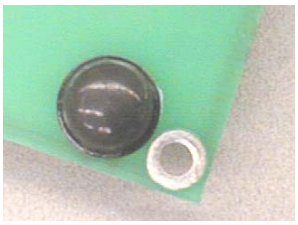
Connecting the Hardware

Both the Board of Education and the BASIC Stamp HomeWork Board come with a strip that has four adhesive rubber feet. These rubber feet are shown in Figure 1-24, and they should be affixed to the underside of your Board of Education or BASIC Stamp HomeWork Board.

Figure 1-24
Rubber Feet

√ Remove each rubber foot from the adhesive strip and affix it to the underside of your board as shown in Figure 1-25. If you are using the Board of Education, it has circles on its underside that show where each rubber foot should be attached. For the HomeWork Board, just place a rubber foot next to each plated hole at each corner.

Figure 1-25
Rubber Foot Affixed to Underside of Board of Education (left) and HomeWork Board (right)



Next, the Board of Education or BASIC Stamp HomeWork Board should be connected to your PC or laptop by a serial cable.

√ Connect your serial cable to an available COM port on the back of your computer as shown in Figure 1-26.

USB Port Adapter If you are using a USB to Serial Adapter:

- √ Connect the USB end to your PC's USB port.
- √ Connect the COM port adapter either directly to your Board of Education or HomeWork Board, or connect it to the serial cable as shown in Figure 1-26.

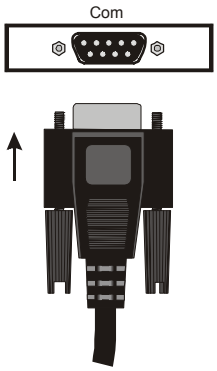


Figure 1-26: PC or Laptop COM Port

Plug the serial cable into an available COM port on your PC or laptop.

Figure 1-27: 3-position Switch

Set to the 0 position to turn off the power.

If you are using the BASIC Stamp 2 module and Board of Education:

- √ Set the 3-position switch on the Board of Education to position-0 as shown in Figure 1-27.

Only the Board of Education Rev C has a 3-position switch. To turn off power on a Board of Education Rev B, simply disconnect the power source by either unplugging the DC supply or the battery These are shown in Figure 1-28, step 3 or 4.

- √ If your BASIC Stamp module is not already plugged into your Board of Education, insert it into the socket, oriented as shown in Figure 1-28, step-1. Make sure the pins are lined up properly with the holes in the socket and not folded under, then press down firmly.
- √ Plug the serial cable into the Board of Education as shown in step-2.

√ Plug a DC power supply into the 6-9 VDC jack as shown in step-3, or plug a 9-V battery into the 9 VDC battery jack as shown in step-4.

√ Move the 3-position switch from position-0 to position-1. The green light labeled Pwr on the Board of Education should now be on.

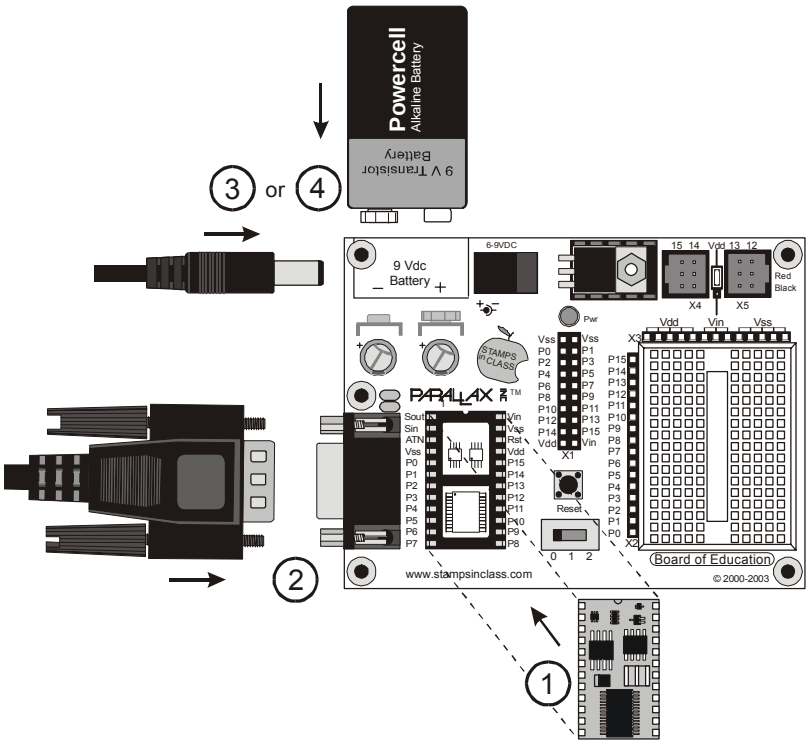


Figure 1-28 Board of Education, BASIC Stamp Module, Battery and Serial Cable.

Connect components in the order shown in the diagram. Make sure to properly orient your BASIC Stamp module right side up, matching the notch on its top edge to notch on the socket.

If you are using the BASIC Stamp HomeWork Board:

√ Connect the serial cable to the HomeWork Board (Figure 1-29, step-1).

√ Connect a 9 V battery to the battery clip as shown in step-2.

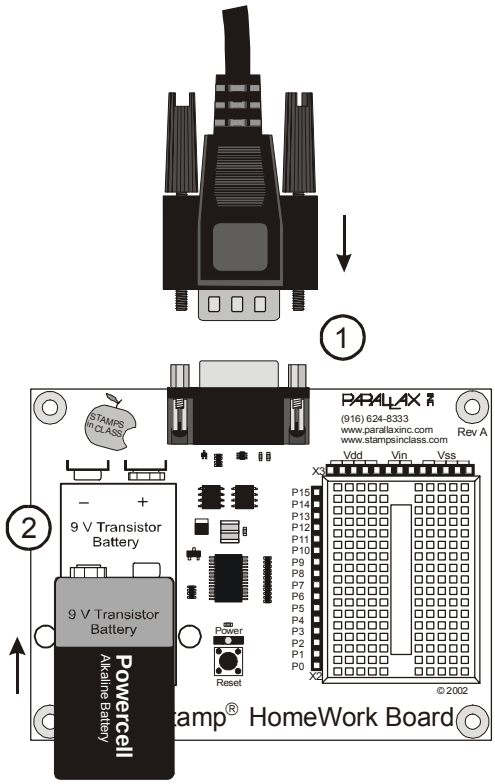


Figure 1-29
HomeWork Board and Serial Cable

Plug the serial cable and 9 V battery into the HomeWork Board.

Testing for Communication

The BASIC Stamp Editor has a feature for testing to make sure your PC or laptop can communicate with your BASIC Stamp module.

√ Double-click the BASIC Stamp Editor shortcut on your desktop. It should look similar to the one shown in Figure 1-30.

Figure 1-30
BASIC Stamp Editor Shortcut

Look for a shortcut similar to this one on your computer's desktop.

The Windows Start Menu can also be used to run the BASIC Stamp Editor. Click your Windows *Start* button, then select *Programs → Parallax, Inc. → BASIC Stamp Editor 2…*, then click the *BASIC Stamp Editor* icon.

Your BASIC Stamp Editor window should look similar to the one shown in Figure 1-31.

The first time you run your BASIC Stamp Editor, it may display some messages and a list of your COM ports found by the software.

√ To make sure your BASIC Stamp module is communicating with your computer, click the *Run* menu, then select *Identify*.

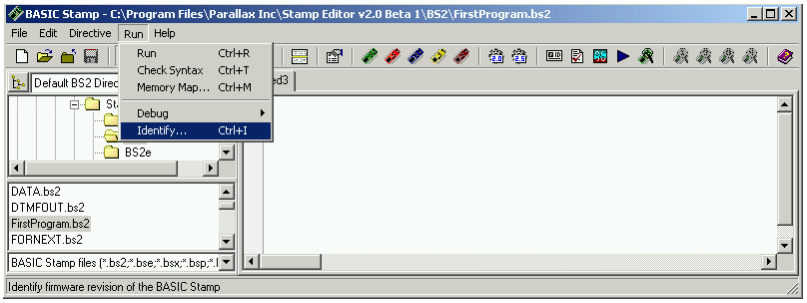


Figure 1-31
BASIC Stamp Editor

Select Identify from the Run menu.

An Identification window similar to the one shown in Figure 1-32 will appear. The example in the figure shows that a BASIC Stamp 2 has been detected on COM2.

√ Check the Identification window to make sure a BASIC Stamp 2 module has been detected on one of the COM ports. If it has been detected, then you are ready for Activity #4: First Program.

√ If the Identification window does not detect a BASIC Stamp 2 module on any of the COM ports, go to Appendix E: Trouble-Shooting on page 315.

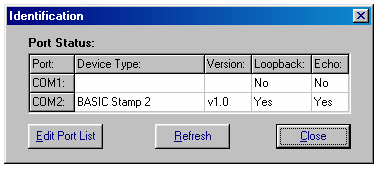


Figure 1-32
Identification Window

Example: BASIC Stamp 2 found on COM2.

ACTIVITY #4: FIRST PROGRAM

The first program you will write and test will tell the BASIC Stamp to send a message to your PC or laptop. Figure 1-33 shows how it sends a stream of ones and zeros to communicate the text characters displayed by the PC or laptop. These ones and zeros are called binary numbers. The BASIC Stamp Editor software has the ability to detect and display these messages as you will soon see.

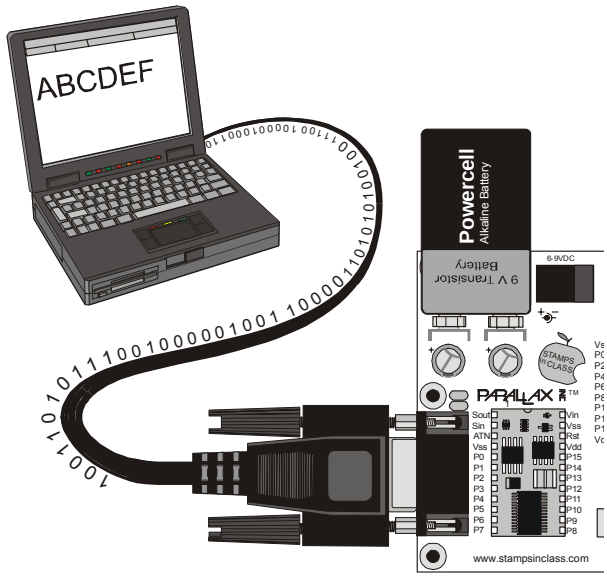


Figure 1-33
Messages from the BASIC Stamp module to your Computer

The BASIC Stamp module sends characters to your PC or laptop by transmitting a stream of binary ones and zeros. The BASIC Stamp Editor can detect and convert these binary codes to characters and display them.

First Program

The program listings that you will type into the BASIC Stamp Editor and download to the BASIC Stamp module will always be shown with a gray background like this:

Example Program: FirstProgram.bs2

```
' What's a Microcontroller - FirstProgram.bs2
' BASIC Stamp sends message to Debug Terminal.

' {$STAMP BS2}
' {$PBASIC 2.5}

DEBUG "Hello, it's me, your BASIC Stamp!"
END
```

You will enter this program into the BASIC Stamp Editor. Some lines of the program are made automatically by clicking buttons on the toolbar. Other lines are made by typing them in from the keyboard.

- √ Begin by clicking the BS2 icon (the green diagonal chip) on the toolbar, shown highlighted in Figure 1-34. If you hold your cursor over this button, its flyover help description "Stamp Mode: BS2" will appear.
- √ Next, click on the gear icon labeled "2.5" shown highlighted in Figure 1-35. It's flyover help description is "PBASIC Language: 2.5".

Figure 1-34
BS2 Icon

Clicking on this button will automatically place " ' {$STAMP BS2}" at the beginning of your program.

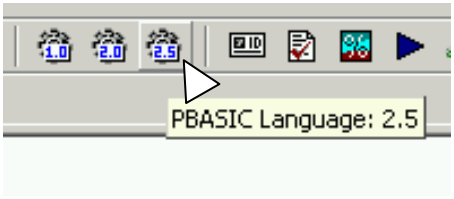


Figure 1-35
PBASIC 2.5 Icon

Clicking on this button will automatically place " ' {$PBASIC 2.5}" at the beginning of your program.

ALWAYS use these toolbar buttons to add these two lines as the beginning of every program! Compiler directives use braces { }. If you try to type in these parts of your program, you may accidentally use parentheses ( ) or square brackets [ ]. If you do this, your program will not work.

- √ Type in the remaining 4 lines of the program exactly as shown in Figure 1-36.

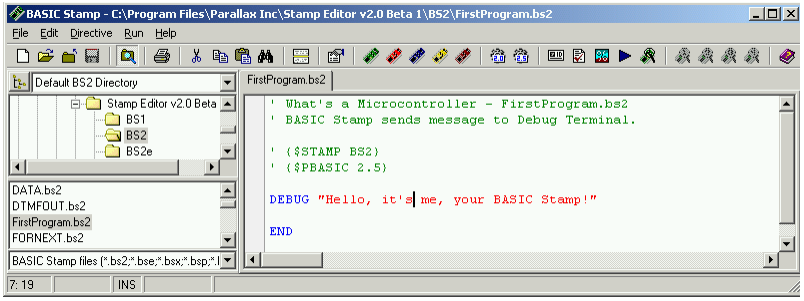


Figure 1-36 First Program Entered into Editor

Enter your first program into the BASIC Stamp Editor as shown here.

√ Save your work by clicking *File* and selecting *Save* as shown in Figure 1-37.
√ Enter the name FirstProgram into the *File name* field near the bottom of the *Save As* window as shown in Figure 1-38.
√ Click the *Save* button.

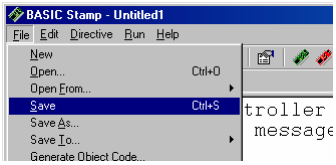


Figure 1-37: Saving the First Program

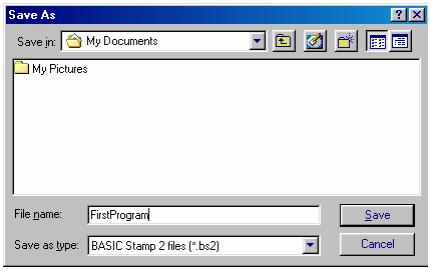


Figure 1-38: Entering the File Name

The next time you save, the BASIC Stamp Editor will automatically save to the same filename (FirstProgram.bs2) unless you tell it to save to a different filename by clicking *File* and selecting *Save As* (instead of just Save).

√ Click *Run*, and select *Run* from the menu that appears (by clicking it) as shown in Figure 1-39.

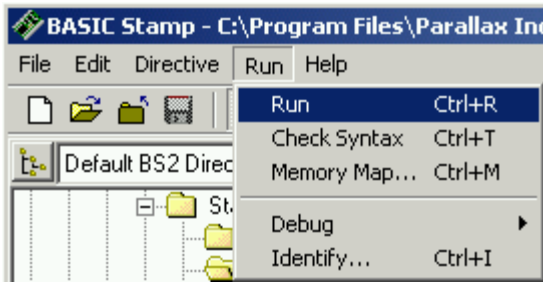


Figure 1-39
Running Your First Program

A Download Progress window will appear briefly as the program is transmitted from the PC or laptop to your BASIC Stamp module. Figure 1-40 shows the Debug Terminal that should appear when the download is complete. You can prove to yourself that this is a message from the BASIC Stamp by pressing and releasing the *Reset* button on your board. Every time you press and release it, the program will re-run, and you will see another copy of the message displayed in the Debug Terminal.

√ Press and release the Reset button. Did you see a second "Hello…" message appear in the Debug Terminal?

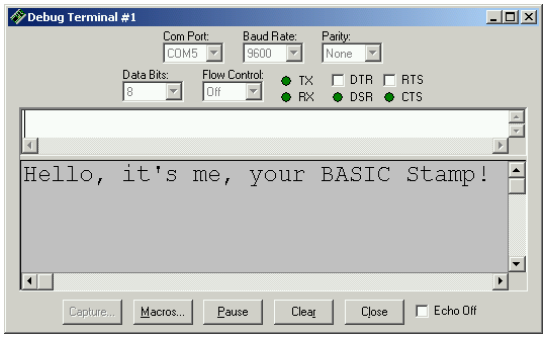


Figure 1-40
Debug Terminal

The Debug Terminal displays messages sent to the PC/laptop by the BASIC Stamp module.

The BASIC Stamp Editor has shortcuts for most common tasks. For example, to run a program, you can press the 'Ctrl' and 'R' keys at the same time. You can also click the *Run* button. It's the blue triangle shown in Figure 1-41 that looks like a CD player's Play button. The flyover help (the Run hint) will appear if you point at the *Run* button with your mouse. You can get similar hints to find out what the other buttons do by pointing at them too.

Figure 1-41

BASIC Stamp Editor Shortcut Buttons

How FirstProgram.bs2 Works

The first two lines in the example are called comments. A comment is a line of text that gets ignored by the BASIC Stamp Editor, because it's meant for a human reading the program, not for the BASIC Stamp module. In PBASIC, everything to the right of an apostrophe is normally considered to be a comment by the BASIC Stamp Editor. The first comment tells which book the example program is from, and the program's filename. The second comment contains a handy, one-line description that explains what the program does.

```
' What's a Microcontroller - FirstProgram.bs2
' BASIC Stamp sends message to Debug Terminal.
```

Although comments are ignored most of the time, the BASIC Stamp Editor does search through comments for special directives. Every program in this text will use these two directives:

```
' {$STAMP BS2}
' {$PBASIC 2.5}
```

The first directive is called the $STAMP Directive, and it tells the BASIC Stamp Editor that you will be downloading the program specifically to a BASIC Stamp 2 module. The second directive is called the $PBASIC directive, and it tells the BASIC Stamp Editor that you are using version 2.5 of the PBASIC programming language. Note that these compiler directives are enclosed in braces { } not parentheses ( ). You should always use the toolbar icons to place these compiler directives in your program to avoid typing errors. Also, entering the compiler directives by hand may not activate the syntax highlighting in the BASIC Stamp Editor. That function is what causes various letters, characters and words in your program to appear in different colors and capitalizations. Syntax highlighting makes your programs easier to read, understand, and correct if there are any bugs in them.

A command is a word you can use to tell the BASIC Stamp do a certain job. The first of the two commands in this program is called the **DEBUG** command:

```
DEBUG "Hello, it's me, your BASIC Stamp!"
```

This is the command that tells the BASIC Stamp to send a message to the PC using the serial cable.

The second command is called the **END** command:

```
END
```

This command is handy because it puts the BASIC Stamp into low power mode when it's done running the program. In low power mode, the BASIC Stamp waits for either the Reset button to be pressed (and released), or for a new program to be loaded into it by the BASIC Stamp Editor. If the Reset button on your board is pressed, the BASIC Stamp will re-run the program you loaded into it. If a new program is loaded into it, the old one is erased, and the new program begins to run.

Your Turn – DEBUG Formatters and Control Characters

A **DEBUG** formatter is a code-word you can use to make the message the BASIC Stamp sends look a certain way in the Debug Terminal. **DEC** is an example of a formatter that makes the Debug Terminal display a decimal value. An example of a control character is **CR**, which is used to send a carriage return to the Debug Terminal. The text or numbers that come after a **CR** will appear on the line below characters that came before it. You can modify your program so that it contains more **DEBUG** commands along with some formatters and control characters. Here's an example of how to do it:

- √ First, save the program under a new name by clicking *File* and selecting *Save As*. A good new name for the file would be FirstProgramYourTurn.bs2
- √ Modify the comments at the beginning of the program so that they read:

```
' What's a Microcontroller - FirstProgramYourTurn.bs2
' BASIC Stamp sends messages to Debug Terminal.
```

- √ Add these three lines between the first **DEBUG** command and the **END** command:

```
DEBUG CR, "What's 7 X 11?"
DEBUG CR, "The answer is: "
DEBUG DEC 7 * 11
```

√ Save the changes you made by clicking *File* and selecting *Save*.

Your program should now look like the one shown in Figure 1-42.

√ Run your modified program. You will have to either select *Run* from the Run menu again, like in Figure 1-39 or click the *Run* button, like in Figure 1-41.

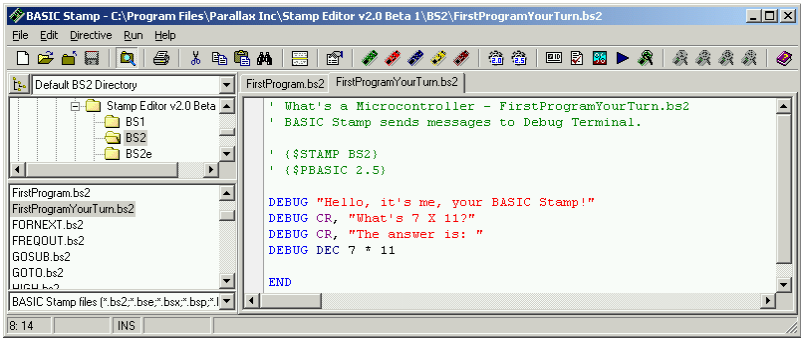


Figure 1-42
Modified FirstProgram

Check your work against the example program shown here.

Where did my Debug Terminal go? Sometimes the Debug Terminal gets hidden behind the BASIC Stamp Editor window. You can bring it back to the front by using the *Run* menu as shown at the left of Figure 1-43, the *Debug Terminal 1* shortcut button shown at the right of the figure, or the F12 key on your keyboard.

Figure 1-43

Debug Terminal 1 to Foreground

Using the menu (left) and using the shortcut button (right).

Your Debug Terminal should now resemble Figure 1-44.

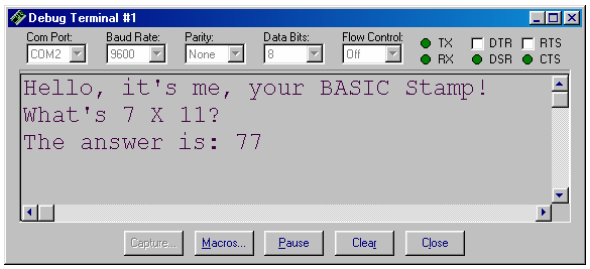


Figure 1-44
Modified FirstProgram.bs2 Debug Terminal Output

Make sure that when you re-run your program, you get the results you expect.

ACTIVITY #5: LOOKING UP ANSWERS

The two activities you just finished introduced two PBASIC commands: **DEBUG** and **END**. You can find out more about these commands and how they are used by looking them up, either in the BASIC Stamp Editor's Help or in the BASIC Stamp Manual. This activity guides you through an example of looking up **DEBUG** using the BASIC Stamp Editor's Help and the BASIC Stamp Manual.

Using the BASIC Stamp Editor's Help

√ In the BASIC Stamp Editor, Click *Help*, then select *Index* (Figure 1-45).

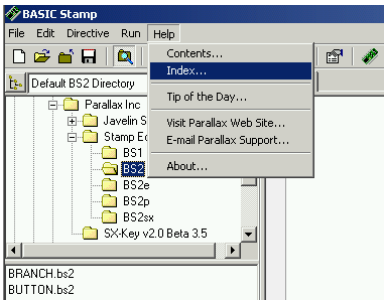


Figure 1-45
Selecting Index from the Help Menu

√ Type DEBUG in the field labeled *Type in the keyword to find:* (Figure 1-46).
√ When the word DEBUG appears in the list below where you are typing, click it, then click the *Display* button.

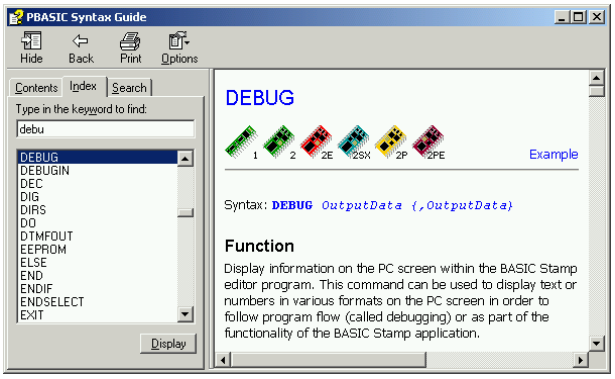


Figure 1-46 Looking up the DEBUG Command Using Help.

Your Turn

- √ Use the scrollbar to review the **DEBUG** command's write-up. Notice that it has lots of explanations and example programs you can try.
- √ Click the *Contents* tab, and find DEBUG there.
- √ Click the *Search* tab, and run a search for the word DEBUG.
- √ Repeat this process for the **END** command.

Getting and Using the BASIC Stamp Manual

The BASIC Stamp Manual is available for free download from the Parallax web site, and it's also included on the Parallax CD. It can also be purchased as a printed book.

Downloading the BASIC Stamp Manual from the Parallax Web Site

- √ Using a web browser, go to www.parallax.com.
- √ Point at the *Downloads* menu to display the options.
- √ Point at the *Documentation* link and click to select it.
- √ On the BASIC Stamp Documentation page, find The BASIC Stamp Users Manual.
- √ Click the *Download* icon that looks like a file folder to the right of the description: "BASIC Stamp User's Manual Version 2.0 (3.2 MB)".

Viewing the BASIC Stamp Manual on the Parallax CD

- √ Click the *Documentation* link.
- √ Click the + next to the BASIC Stamps folder.
- √ Click the BASIC Stamp Manual book icon.
- √ Click the *View* button.

√ Figure 1-47 shows an excerpt from the *BASIC Stamp Manual* v2.0 Contents section, showing that information on the **DEBUG** command is found on page 97.

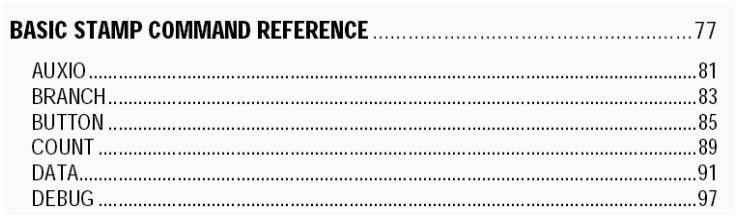
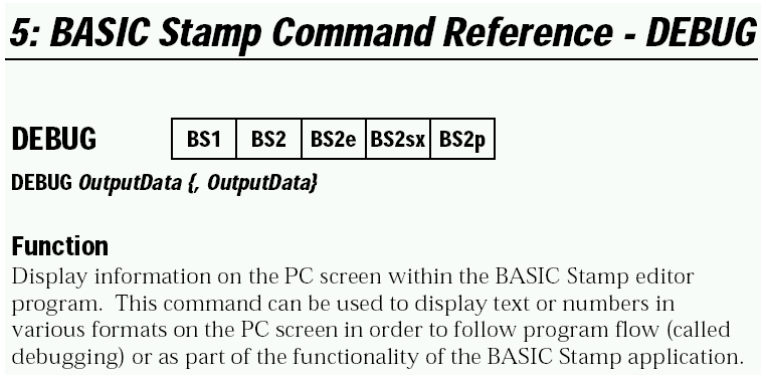

BASIC STAMP COMMAND REFERENCE 77
AUXIO 81
BRANCH 83
BUTTON 85
COUNT 89
DATA 91
DEBUG 97

Figure 1-47 Finding the DEBUG Command in the Table of Contents

Figure 1-48 shows an excerpt from page 97 in the BASIC Stamp Manual v2.0. The **DEBUG** command is explained in detail here along with example programs to demonstrate how the **DEBUG** command can be used.

√ Look over the *BASIC Stamp Manual's* explanation of the **DEBUG** command.
√ Count the number of example programs in the **DEBUG** section. How many are there?



5: BASIC Stamp Command Reference - DEBUG

DEBUG | BS1 | BS2 | BS2e | BS2sx | BS2p

DEBUG *OutputData {, OutputData}*

Function

Display information on the PC screen within the BASIC Stamp editor program. This command can be used to display text or numbers in various formats on the PC screen in order to follow program flow (called debugging) or as part of the functionality of the BASIC Stamp application.

Figure 1-48 Reviewing the **DEBUG** Command in the BASIC Stamp Manual

Your Turn

- √ Use the BASIC Stamp Manual's Index to look up the **DEBUG** command.
- √ Look up the **END** command in the BASIC Stamp Manual.

ACTIVITY #6: INTRODUCING ASCII CODE

In Activity #4, you used the **DEC** formatter with the **DEBUG** command to display a decimal number in the Debug Terminal. But what happens if you don't use the **DEC** formatter with a number? If you use the **DEBUG** command followed by a number with no formatter, the BASIC Stamp will read that number as an ASCII code.

Programming with ASCII Code

ASCII is short for American Standard Code for Information Interchange. Most microcontrollers and PC computers use this code to assign a number to each keyboard function. Some numbers correspond to keyboard actions, such as cursor up, cursor down, space, and delete. Other numbers correspond to printed characters and symbols. The numbers 32 through 126 correspond to those characters and symbols that the BASIC Stamp can display in the Debug Terminal. The following program will use ACSII code to display the words "BASIC Stamp 2" in the Debug Terminal.

Example Program – ASCIIName.bs2

- √ Enter and run ASCIIName.bs2.

Remember to use the toolbar icons to place Compiler Directives into your programs!

`'{$STAMP BS2}` - Use the diagonal green electronic chip icon.
`'{$PBASIC 2.5}` - Use the gear icon labeled 2.5.

You can see a picture of these icons again on page 21.

```
'What's a Microcontroller - ASCIIName.bs2
'Use ASCII code in a DEBUG command to display the words BASIC Stamp 2.

'{$STAMP BS2}
'{$PBASIC 2.5}

DEBUG 66,65,83,73,67,32,83,116,97,109,112,32,50

END
```

How ASCIIName.bs2 Works

Each letter in the **DEBUG** command corresponds to one ASCII code symbol that appeared in the Debug Terminal.

```
DEBUG 66,65,83,73,67,32,83,116,97,109,112,32,50
```

66 is the ASCII code for capital "B", 65 is the code for capital "A" and so on. 32 is the code for a space between characters. Notice that each code number was separated with a comma. The commas allow the one instance of **DEBUG** to execute each symbol as a separate command. This is much easier to type than 12 separate **DEBUG** commands.

Your Turn – Exploring ASCII Code

- √ Save ASCIIName.bs2 as ASCIIRandom.bs2
- √ Pick 12 random numbers between 32 and 127.
- √ Replace the ASCII code numbers in the program with the numbers you chose.
- √ Run your modified program to see what you get!

The *BASIC Stamp Manual* Appendix A has a chart of ASCII code numbers and their corresponding symbols. You can look up the corresponding code numbers to spell your own name.

- √ Save ASCIIRandom.bs2 as YourASCIIName.bs2
- √ Look up the ASCII Chart in the BASIC Stamp Manual.
- √ Modify the program to spell your own name.
- √ Run the program to see if you spelled your name correctly.
- √ If you did, good job, and save your program!

ACTIVITY #7: WHEN YOU'RE DONE

It's important to disconnect the power from your BASIC Stamp and Board of Education (or HomeWork Board). First, your batteries will last longer if the system is not drawing power when you're not using it. Second, soon you will build circuits on the Board of Education or HomeWork Board prototyping area.

Circuit prototypes should never be left unattended with a battery or power supply connected. **Always disconnect the power** from your Board of Education or HomeWork Board before you walk away, even if you only plan on leaving it alone for a minute or two.

Disconnecting Power

With the Board of Education Rev C, disconnecting power is easy. If you are using the Board of Education Rev C, power is disconnected by moving the 3-position switch to position-0 by pushing it to the left as shown in Figure 1-49.

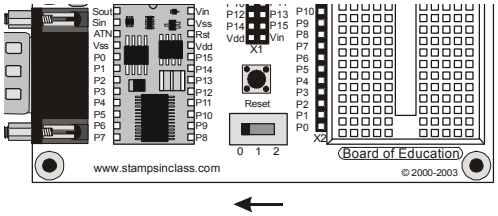


Figure 1-49
Turning the Power off

Board of Education Rev C

Do not remove the BASIC Stamp module from its socket in the Board of Education! Every time the BASIC Stamp is removed and re-inserted into the socket on the Board of Education, you risk damaging it. You do not need to remove it for storage.

Disconnecting the BASIC Stamp HomeWork Board's power is easy too. If you are using the BASIC Stamp HomeWork Board, disconnect the battery as shown in Figure 1-50.

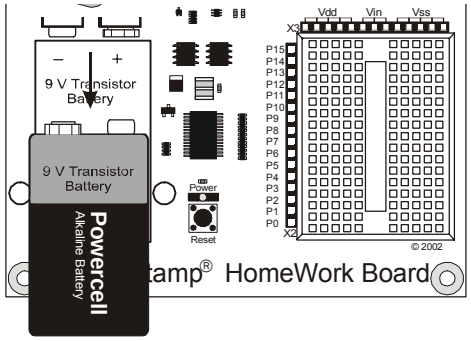


Figure 1-50
Disconnecting the power to the HomeWork Board

If you are using a Board of Education Rev B, you will not have a 3-position switch. Either unplug power supply, or remove the 9 V battery, whichever you are using.

Your Turn

√ Disconnect the power to your board now.

SUMMARY

This chapter guided you through the following:

- An introduction to some devices that contain microcontrollers
- An introduction to the BASIC Stamp module
- A tour of some interesting inventions made with BASIC Stamp modules.
- Where to get the free BASIC Stamp Editor software you will use in just about all of the experiments in this text
- How to install the BASIC Stamp Editor software
- An introduction to the BASIC Stamp module, Board of Education, and HomeWork Board
- How to set up your BASIC Stamp hardware
- How to test your software and hardware
- How to write and run a PBASIC program
- Using the **DEBUG** and **END** commands
- Using the **CR** control character and **DEC** formatter
- How to use the BASIC Stamp Editor's Help and the BASIC Stamp Manual
- A brief introduction to ASCII code
- How to disconnect the power to your Board of Education or HomeWork Board when you're done.

Questions

1. What is a microcontroller?
2. Is the BASIC Stamp module a microcontroller, or does it contain one?
3. What clues would you look for to figure out whether or not an appliance like a clock radio or a cell phone contains a microcontroller?
4. What does an apostrophe at the beginning of a line of PBASIC program code signify?
5. What PBASIC commands did you learn in this chapter?
6. Let's say you want to take a break from your BASIC Stamp project to go get a snack, or maybe you want to take a longer break and return to the project in a couple days. What should you always do before you take your break?

Exercises

1. Explain what the asterisk does in this command:

```
DEBUG DEC 7 * 11
```

2. Guess what the Debug Terminal would display if you ran this command:

```
DEBUG DEC 7 + 11
```

3. There is a problem with these two commands. When you run the code, the numbers they display are stuck together so that it looks like one large number instead of two small ones. Modify these two commands so that the answers appear on different lines in the Debug Terminal.

```
DEBUG DEC 7 * 11
DEBUG DEC 7 + 11
```

Projects

1. Use **DEBUG** to display the solution to the math problem: 1 + 2 + 3 + 4.
2. Which lines can you delete in FirstProgramYourTurn.bs2 if you place the command shown below on the line just before the **END** command in the program? Test your hypothesis (your prediction of what will happen). Make sure to save FirstProgramYourTurn.bs2 with a new name, like FirstProgramCh01Project05.bs2. Then make your modification, save and run your program.

```
DEBUG "What's 7 X 11?", CR, "The answer is: ", DEC 7 * 11
```

Solutions

Q1. A microcontroller is a kind of miniature computer found in electronic products.
Q2. The BASIC Stamp module contains a microcontroller called the PIC16C57.
Q3. If the appliance has buttons and a digital display, these are good clues that it has a microcontroller inside.
Q4. A comment.
Q5. **DEBUG** and **END**
Q6. Disconnect the power from the BASIC Stamp project.
E1. It multiplies the two operands 7 and 11, resulting in a product of 77. The asterisk is the multiply operator.
E2. The Debug Terminal would display: 18
E3. To fix the problem, add a carriage return, the **CR,** control character.

```
DEBUG DEC 7 * 11
DEBUG CR, DEC 7 + 11
```

P1. Here is a program to display a solution to the math problem: 1+2+3+4

```
'{$STAMP BS2}
'{$PBASIC 2.5}
```

```
DEBUG "What's 1+2+3+4?"
DEBUG CR, "The answer is: "
DEBUG DEC 1+2+3+4

END
```

P2. The last three **DEBUG** lines can be deleted. An additional **CR** is needed after the "Hello" message.

```
' What's a Microcontroller - FirstProgramYourTurn.bs2
' BASIC Stamp sends message to Debug Terminal.

' {$STAMP BS2}
' {$PBASIC 2.5}

DEBUG "Hello, it's me, your BASIC Stamp!", CR

DEBUG "What's 7 X 11?", CR, "The answer is: ", DEC 7 * 11

END
```

The output from the Debug Terminal is:

```
Hello, it's me, your BASIC Stamp!
What's 7 X 11?
The answer is: 77
```

This output is the same as it was with the previous code. This is an example of using commas to output a lot of information, using only one **DEBUG** statement.

Further Investigation

In this chapter, you visited the Software section of either the Parallax web site or the Parallax CD to get a copy of the BASIC Stamp Editor. You can go to the Documentation sections of either the Parallax web site or the Parallax CD to get a free copy of this text and of the *BASIC Stamp Manual*. Printed copies can also be purchased from Parallax.

***"BASIC Stamp Manual"*, Users Manual, Version 2.0c, Parallax Inc., 2000**

You can learn much more about the **DEBUG** and **END** commands by looking them up in the *BASIC Stamp Manual*. You can find them using the Table of Contents. The *BASIC Stamp Manual* has many more examples you can try, along with lessons similar to those in the Projects section you just completed.